Study on moving ground data processing tasks associated with NASA's Polar, Wind and Geotail satellites and mission operations of the Polar and Wind spacecraft to the University of California at Berkeley's Space Science Laboratory (SSL)

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Executive Summary

The University of Califonia at Berkeley's Space Science Laboratory (SSL) has substantial experience in supporting and developing satellite data systems and mission operations. As outlined below, SSL has operated several spacecraft. In particular, at NASA's request, SSL oversaw the transfer of mission and data operations of EUVE and FAST from Goddard to Berkeley. These transfers involved bringing existing systems from Goddard to Berkeley.

The Mission and Science Operations Center (MSOC) at SSL currently operates the FAST satellite and will soon be responsible for HESSI. This facility provides the infrastructure and experienced staff required to take on the tasks oulined here. Additional personnel may be required which we plan to acquire both from staff at GSFC that may want to come to Berkeley and by job announcement.

SSL has evaluated the project requirements document. We propose to take over the duties currently performed by the MOC, RLZP, and CDHF with some modifications. For instance, we will not produce the Key Parameter (KP) files. We will not take over the duties of the Flight Dynamics Facility (FDF) or those of the Instrument and Spacecraft Engineers.

Our philosophy in this study is to minimize reengineering costs by taking as many systems from Goddard "as is." Reengineering of the CDHF will be required. A reengineering effort already underway at Goddard on the Command Management System (CMS) should be completed before we transfer that system to Berkeley.

Introduction and Motivation

NASA's Senior Review of Operating Satellite Projects recommended in 2001 the continued operation of full Polar Science Operations and limited operations of the Geotail and Wind spacecraft. Responsibility and funding for continued operations of the associated ISTP Command and Data Handling Facility (CDHF) were transferred to the Polar Project Office, and the ISTP office effectively disbanded. The funds for operations and data analysis were restricted, and the Polar Project was encouraged to look for significant costs savings.

Dr. R. Lin at the Space Sciences Laboratory (SSL) at the University of California at Berkeley informed the Polar Project of the extensive experience of the Lab in operations and ground data processing for NASA. Peter Schroeder, head of Wind/3DP operations for SSL, Tim Quinn, head of FAST science operations, and Mark Lewis, head of FAST mission operations, were chosen to investigate costs savings measures for SSL.

Mr. Schroeder at SSL as well as groups at NASA/Goddard (headed by Bob McGuire), the Univesity of Colorado (Dr. W.K. Peterson), and NASA/Marshall (headed by Dr. Dennis Galagher) were encouraged by Dr. Robert Hoffman, Polar Project Scientist, to work together to analyze and determine what portion of the mission operations and ground data processing tasks could be efficiently moved from the existing CDHF facility. A requirements document was formulated to provide a clear discussion of what tasks currently done by the CDHF and other Goddard organizations must be continued in a timely and reliable manner.

Mr. Schroeder paricipated in a series of discussions and data exchanges with Barbara Giles (Deputy Polar Project Manager), McGuire and Peterson to determine where the work could be done most efficiently. These discussions revealed different approaches to meeting the requirements outlined in the Requirements Document. No clearly preferable approach was identified. We decided, therefore, to produce independent informal studies of the approach, schedule, and costs for various portions of the work to be performed at each institution for evaluation by the Polar Project.

Overview of Ground Data Processing and Mission Operations at SSL

SSL investigators have been involved in NASA-supported space research for 43 years. UC Berkeley has a long history of supporting both the mission and science operations for numerous NASA spacecraft, as well as proposing and implementing transition of operations from GSFC to Berkeley. Missions we have supported or are supporting include EUVE, FAST, HESSI, Image, Cluster, Geotail, ISUAL, CHIPS, and Stereo/Impact.

Science operations for the Extreme Ultraviolet Explorer (EUVE) began in 1992 and was followed in 1996 by the the transition of mission operations from GSFC to Berkeley. The Berkeley Flight Operations Team (FOT) championed a low-cost operations model which included automated monitoring/paging. Numerous systems associated with the EUVE program are the same as those used by Wind and Polar. These include TPOCC, the telemetry and command control system, and the Command Management System (CMS). EUVE operations personnel with experience operating these systems have moved into operations positions for the FAST and HESSI programs and would be available for the transition of Wind/Polar operations to Berkeley.

In 1996, a fully autonomous science operations center began operation with the launch of the FAST spacecraft. Using the EUVE transition as a model, the transition of mission operations from GSFC to Berkeley occurred in 1999 with the creation of the Berkeley Mission and Science Center (MSOC). This will be followed by the transition of Flight Dynamics and Level Zero Processing from GSFC to Berkeley in 2002.

In parallel with the transition of FAST mission operations to Berkeley, HESSI mission and science operations were developed and integrated into the MSOC. The MSOC is part of a larger Ground Data System (GDS) which includes an 11-meter ground station which will support HESSI and is currently supporting FAST and Image.

The MSOC is currently supporting the CHIPS mission during I&T and will continue mission operations. Future missions include Stereo/Impact.

For all of the missions mentioned, Berkeley has implemented autonomous operations wherever possible. This includes fully autonomous science operations for FAST and HESSI. Mission operations for both FAST and HESSI are nearly fully autonomous allowing for a small multi-mission team which is available from 9-5, Monday through Friday. For times outside the normal working hours, autonomous systems perform limit checking and spacecraft state of health checks and contact personnel by page if problems arise.

Mission & Science Operations Center (MSOC)

Facility Description

The Berkeley Mission and Science Operations Center (MSOC) is located at the Space Sciences Laboratory (SSL) on the Campus of the University of California at Berkeley. The Berkeley MSOC serves as the satellite control and data archiving facility for a number of different missions and has been designed to support multiple spacecraft operations. The backbone of the Berkeley

MSOC is suite of workstations connected through a secure, isolated local area network. Currently, data from the Fast Auroral Snapshot Explorer (FAST) are archived at the MSOC. FAST is a NASA Small Explorer (SMEX) mission and was launched on August 21, 1996.

Another Small Explorer spacecraft, the High Energy Solar Spectroscopic Imager (HESSI), is currently under development at SSL and will be launched in January of 2002.

The Berkeley MSOC fully supports Mission and Science Operations for both FAST and HESSI. All critical elements of the HESSI Ground Data System, including the equipment racks for the Berkeley Ground Station, are housed inside the Berkeley MSOC.

The Berkeley Ground Station also provides support of the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission. During times when no support of HESSI or FAST is scheduled, the ground station receives real-time data from the Far Ultraviolet Wideband Imaging Camera (FUV WIC) on board the IMAGE spacecraft. This instrument, built by the IMAGE FUV group at SSL, provides far ultraviolet images of the northern aurora every two minutes. IMAGE is a NASA Medium-class Explorer (MIDEX) mission and was launched on March 25, 2000.

Flight Operations Consoles

Personnel at the flight operations consoles monitor spacecraft health and safety and prepare command loads that are uplinked to the spacecraft during a ground station contact. Spacecraft locations provided by SatTrack in real-time are displayed on a projected screen.

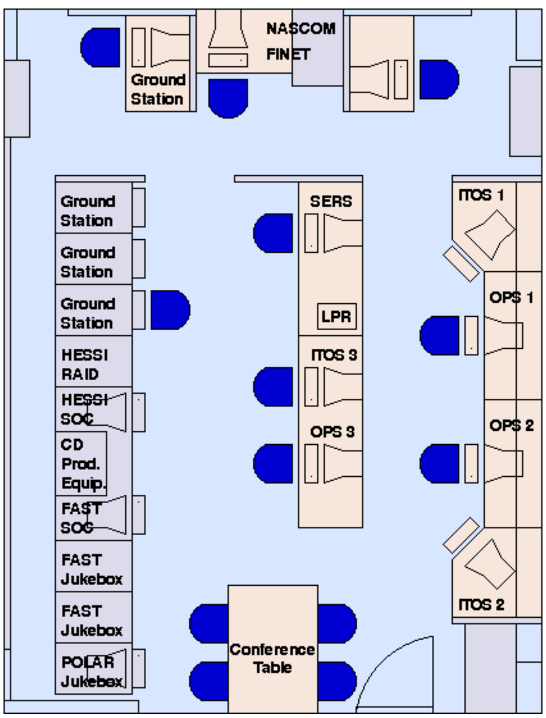

Figure 1 -- Diagram of the MSOC

Science Operations and Satellite Data Archiving Area

The second row of consoles is the science operations area where operators monitor the telemetry data streams from the science payloads and perform level-zero processing. This row also houses a computer which serves as the Spacecraft Emergency Response System (SERS). SERS monitors all other critical subsystems inside the facility, as well as spacecraft status and health. It notifies operations personnel in case of anomalies via a sophisticated paging system. The satellite data archiving area consists of several workstations, a fully autonomous CD-ROM production system, and two racks which currently have 9 jukeboxes. These juke boxes contain all data obtained from the FAST mission. The total data volume to date is 1.4 Terabytes and is constantly growing

Security

The SSL Mission Operations Center is very secure. The MOC is physically secured via a hey card system. Inside the MOC, an alarm system monitors the door and includes motion detectors. Closed circuit cameras monitor the MOC and the Berkeley Ground Station. Access to the MOC is restricted to operations personnel exclusively. Visitors, including PI's, require escort while in the MOC.   All crucial mission operations hardware is protected by a firewall, UPS's, and a backup generator. The Berkeley FOT undergoes extensive screening and training in building and IT security.

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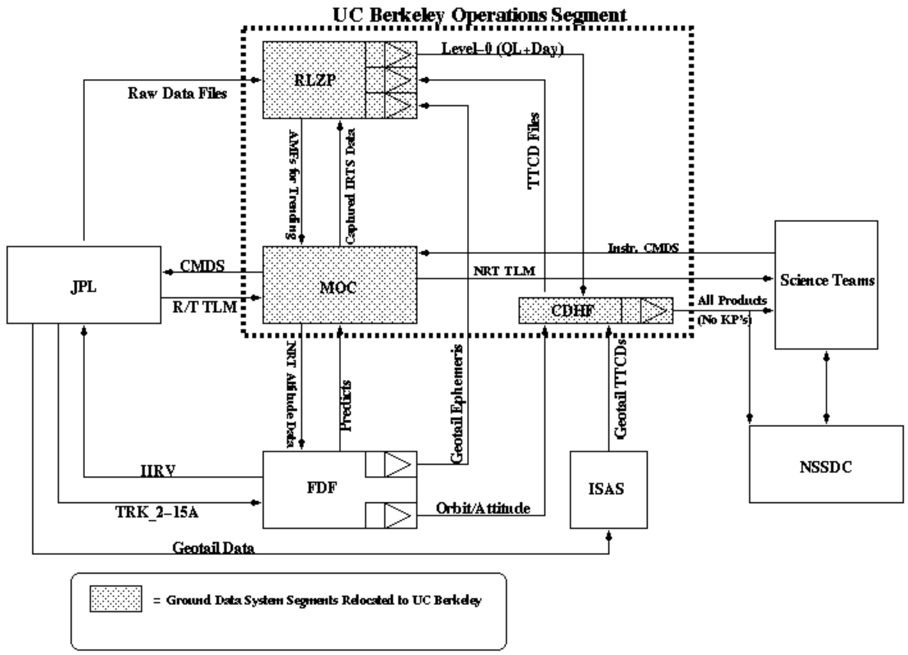
Figure 2 - Operators in the MSOC



– Updated ISTP Data Flow –

Approach to Ground Data Processing

We anticipate drawing personnel from existing Berkeley staff with data processing experience while relying on our rich pool of graduating undergraduates who make up a much of our current staff.

Two ground data personnel will be trained at Goddard for a period of a month. There they will learn about the policies and procedures in place that run the RLZP and CDHF functions that will be performed at SSL. They will train the other ground data staff upon their return.

Our approach to the design will be to minimize the amount of "hands on" attention required to run the ground data processing system. We will rely on automated scripts. Our operators are primarily undergraduate students with a supervisory layer of experienced software and operations professionals.

We will also minimize the reengineering of the RLZP function currently being performed at Goddard. We intend to implement the code on hand to perform this function. The bulk of the reengineering will be to the duties of the former CDHF.

All work will be done under the supervision of Peter Schroeder. Dr. Lin will be consulted regarding interface issues, but not be involved in the detailed development, operations or supervision effort.

NUMBERS BELOW REFER TO SECTIONS AND PARAGRAPHS IN THE REQUIREMENTS DOCUMENT

1: Science Operations Planning

1.2: Predictive and Definitive Orbit Information

We will obtain Wind and Polar 70 day predictive orbit and attitude data from the Goddard Flight Dynamics Facility in TBD formats on a scheduled basis. We will obtain similar data for Geotail from ISAS in TBD formats also on a scheduled basis.

We will convert these data to CDF files and package in 70 day and 1 day CDF files. We DO NOT plan to produce the associated SFDU files because there is a lack of documented use of the SFDUs and because the maintenance of the CDF/SFDU pairs is complex. We will produce 9 different file types:

po_or_pre wi_or_pre ge_or_pre
po_at_pre wi_at_pre ge_at_pre
po_or_lng wi_or_lng ge_or_lng

We will obtain Geotail definitive orbit and attitude data from ISAS in a TBD format. We will convert these data to CDF files and produce 2 different file types:

ge_or_def
ge_at_def

We will NOT produce the associated SFDU files.

We will NOT produce the Polar despun platform attitude data files, either predictive or definitive. These files are used by the three imaging investigational teams. The production of these files require detailed knowledge of the platform operation and operational history. We believe that the production of these files would best be done by one of the imaging teams.

If the responsible NASA officials determine that the predictive orbit and attitude data are inadequate for data analysis, we will produce updated versions of the orbit and attitude files as required.

1.3: Polar Despun Platform Pointing Planning

We will work with the individuals who generate the Polar despun platform planning files to make sure they have timely access to the Polar orbit and attitude files required for their work. These files are used by the three imaging investigational teams. The production of these files require detailed knowledge of the platform operation and operational history. We will NOT produce these files.

3.6: Continuation of Quicklook Products

The Quicklook (QL) data product is a level zero file created from a tape recorder dump. The tape dumped recorder data are physically located at JPL and can be pulled to the ground processing center with approprate notification. The same software which produces 24-hour level zero data files can produce the Quicklook data files. The QL files differ from the LZ files only in file name, start and stop UT, and the extra work involved in obtaining the tape recorder data from JPL.

We will have the capability of providing QL data products for all the Polar and Wind (not Geotail) instruments from tape recorder data. We will provide this service ONLY at the request of Dr. R.A. Hoffman to support instrument anomalies and public relations imaging sequences. The costs outline below assume that ~10 requests will be made annually.

We will provide QL data files on line or by email to designated recipients.

3.7: Data Processing, Archiving, and Distribution

We will work with JPL and NASA/Goddard to adapt existing procedures for transfer of telemetry files of Polar and Wind level zero data by ftp to computers at SSL.

We will develop procedures to acquire from the Polar and Wind operations center at SSL or elsewhere near real time level zero data as a backup to the level zero data from JPL. These files will be used to fill gaps in the tape recorder dumps or other anomalies in the data stream from JPL.

We will work with ISAS and Goddard to adapt existing procedures for the transfer of telemetry files from Geotail by ftp to computers at SSL.

We will adapt existing codes and procedures provided by Goddard to assemble 24-hour telemetry files for Polar, Wind, and Geotail from spacecraft tape recorder dumps, near real time (NRT) pass data, and ISAS (Geotail). We will make a best effort to provide quality checking but will rely primary on PI teams for quality validation.

We will produce the following LZ data products:

Polar: cep, efi, hyd, mfe, pix, pwi, qaf, scr, tid, tim, uvi, vis
Wind: 3dp, epa, kon, mfi, qaf, scr, sms, swe, tgr, wav
Geotail: cpi, efd, epi, hep, lep, mgf, pwi, qaf, scr

We will provide capability for re-processing.

We will adapt existing software to make the following attitude files, but not the associated SFDU files, currently produced at the CDHF:

po_k0_spha
wi_k0_spha
ge_k0_spha

To minimize operational complexity, we will maintain files for each data product in one format only. For this reason, we will NOT produce sirius level zero files for Geotail or associated SFDU files for any data products.

We will maintain _or, _at, _lng, _lz, and _spha data files on a server for remote “pull down” by PI teams. We will provide approximately 30 days of the larger _lz files and approximately 90 days of the other files on line. This server will have a modest level of security. No provision for restricting access to data types by PI group will be made.

We will provide a modest level of data backup and archiving. We will make two full sets on CDROM of all data products produced at SSL. One set will be sent to NSSDC for archiving and one set retained locally for backup. No attempt will be made to make sure that all data files for a given day appear on the same physical CDROM. We will maintain an index, in simple ASCII listing format, of data names (including date information) on each CDROM.

After 30 days, primary access to LZ data products will be through the NSSDC deep archive.

3.8: Spacecraft Health and Safety Data Processing

We have already mentioned the production of the spacecraft health and safety data products (qaf, scr, and spha) above in section 3.7.

3.9: KP Generation

The po/wi/ge_k0_spha files are named as key parameter files but are actually attitude files and will be produced and distributed as discussed in other sections. Other Key Parameter (KP) files are instrument specific. They require a detailed knowledge of the instrument and operational history. We believe these data products are best produced by groups with easy and direct access to the many individuals holding undocumented knowledge about the state and operation of the various instruments. We will not undertake the difficult and complex task of porting existing KP software to a new environment.

3.10: Definitive Orbit and Attitude Data

Definitive orbit and attitude data for Polar and Wind were discontinued previously as part of an earlier re-engineering effort. If the responsible NASA officials determine that predictive orbit and attitude data are inadequate for data analysis, we will produce updated versions of the attitude and orbit files as required.

As discussed in section 1.2 above, we will produce and distribute Geotail definitive orbit and attitude data from inputs provided by ISAS.

3.12: Data Distribution

We will acquire command history logs from the Polar and Wind spacecraft operations group and make a modest effort to acquire the same information from the Geotail operations group. We will format these data in a TBD format, not necessarily identical to the format that has been used and provide them on line.

As discussed in section 3.7, we will provide an ftp server or equivalent with 30 days of large files and 90 days of small files (including command history files), where PI teams can access and "pull down" data they require. We will NOT support "pushing" files to PI sites using scripts running at SSL. We will provide access to all files to all persons authorized by individual PI's. It will therefore be possible for anyone with access to the server to pull down data from all Polar, Wind, and Geotail investigations.

On request of and with appropriate supplemental funding from the Polar project scientist, we will make custom CD's for Polar and Wind PI teams.

Estimate of costs of Ground Data Processing

Costs are shown here as man-months (mm), man-weeks (mw) or full time equivalents (FTE). A summary of translation to dollars is given at the end of this study.

Development:

1.2 Develop procedures and adapt existing software to obtain and reformat Polar, Wind, and Geotail orbit and attitude files 1 mm

1.3 Despun platform planning interface 1 mw

3.6 Quicklook data products 1 mw

3.7 Data processing, archiving, and distribution 3 mm

3.12 CD production 1 mw

Additional training at Goddard on RLZP and CDHF systems 2 mm

Subtotal: 7 mm

Validation/Transition:

1.2 Validate orbit and attitude file generation 1 mw

1.3 Despun platform plannuing interface nil

3.6 Quicklook data products 1 mw

3.7 Data processing, archiving, and distribution 1 mm

3.12 CD production 1 mw

14 weeks of Transition of Production/Processing Personnel 10.2 mm

Subtotal: 12 mm

Production/Processing:
1.2 Orbit and attitude processing included in 3.7
1.3 Despun platform planning interface nil
3.7 Data processing, archiving, and distribution 3 FTE
3.12 CD production included in 3.7
Subtotal: 3 FTE

Travel Costs: 2 people 1 month at Goddard ~5K$
On going material costs ~5K$/year
Required additional hardware:
4 Sun Workstations - $12K
2 Uninteruptible Power Supplies (UPS) - $0.4K
Disk Storage - $5K
Total: $17.4K

Approach to Operations

Our approach to the design will be to minimize the amount of reengineering involved. We will use the Govenment Funished Equipment (GFE) program wherever possible. We would like to transfer the TPOCC system used by Polar/Wind operations to Berkeley if possible or a replacement will need to be found. We propose that GSFC complete its reengineering of the CMS and, then, bring it Berkeley. Delays in acquiring this equipment would delay our timeline.

The Space Sciences Lab is currently supporting operations for FAST and HESSI with a team of full-time professionals and half-time students. This team includes four members of the EUVE FOT, whose experience in transitioning operations and with the TPOCC ground system will be invaluable. The team also has experience with DSN scheduling and CMS. The Wind/Polar FOT will be drawn from these experienced satellite operators and augmented with students eager to learn. Cross-training the FOT between several missions produces a team which is versatile and motivated.

The two Spacecraft Controllers will train at Goddard for two months to learn the policies and procedures in place at the MOC. In particular, they will be trained on the CMS and TPOCC systems. After they return to SSL, they will spend two months training their backups who will primarily be members of the FAST and HESSI teams. Additionally, the DSN controller will train at Goddard for a month.

A particular strength of the SSL operations is that ongoing training is fundamentally built into the system because of the demands of educating the constant flux of student operators that pass through the system. This means that we have well documented software, procedures, and policies we rely heavily on.

All work will be done under the supervision of Peter Schroeder. Dr. Lin will be consulted regarding interface issues but not be involved in the detailed development, operations or supervision of the effort.

1.4 Submission of Command Sequences by Instrument Team

We will obtain and adapt existing documentation, code, and procedures and implement them to run on SSL computers to support the following Operations Planning tasks:

Obtain e-mails of commanding sequences from PI teams and strip headers

Obtain the polar platform pointing plan from the platform team

Obtain eclipse times from FDF

Obtain parameters for flip and attitude maneuvers from FDF and Polar and Instrument Engineers at GSFC

Obtain information about battery health and safety

Obtain requirements from Spacecraft and Instrument engineers about requirements for special operations

We will merge commanding sequences from the above inputs. Command loads will be checked by at least two people. Command loads for special operations will be checked by the Spacecraft and Instrument Engineers at Goddard..

We will generate command history logs and provide them to the data archive in a TBD format.

We would like GSFC to complete its reengineering of the CMS system and, then, bring that system to Berkeley. Also, we would acquire the current TPOCC system through the Government Furnished Equipment (GSE) program, or a replacement would need to be found.

The primary source for assistance for PI teams in building commands in response to instrument anomalies will remain with the Instrument Engineers at Goddard. We will work with the Instrument Engineers and PI teams as required to generate new command sequences in response to instrument anomalies.

2.1 Preparation of Spacecraft and Instrument Commanding Sequences

We will provide procedures for PI teams to transfer validated instrument specific memory loads to be sent to their instruments in real time. We will support the intensive uploading requirements of the Polar/VIS instrument and emergency uploading requirements of other investigators within the resources available to us.

Geotail commanding and operations will continue to be performed by ISAS.

2.3 DSN Scheduling

We will adapt existing procedures to develop and implement work with DSN to develop Polar/Wind DSN scheduling for Polar and Wind operations.

We will keep on-line logs of contact times on a web site accessible to Polar and Wind PI's so they can efficiently plan their infrequent near real time commanding sessions.

If specifically requested by NASA, we will investigate what additional effort is required to perform the DSN scheduling task for Geotail operators physically located in Japan.

2.4 Special Operations Planning Scheduling

We will work with Polar Instrument Engineers at GSFC and Polar PI's to develop flip plans for 3/02 (half flip to ecliptic normal), 9/02 (half flip to orbit normal), 3/03 (full flip), 10/03 (half flip to ecliptic normal) and thereafter at regular intervals to develop plans and procedures for trim maneuvers to maintain Polar in an ecliptic normal attitude.

We will develop and submit for review command sequences to implement maneuvers to cognizant engineers at Goddard.

We will work with WIND Engineers and PI's to develop and implement orbit trim maneuvers.

We will adapt and implement existing plans and procedures for dealing with spacecraft and instrument emergencies.

We will schedule regular teleconferences with Goddard engineers to make sure emergency response plans are current.

We will work with the Instrument and Spacecraft Engineers at Goddard to analyze instrument and spacecraft anomalies and develop plans to resolve them.

We will maintain emergency contact information for PI teams as well as for cognizant Polar and Wind Spacecraft Engineers at Goddard.

3.1 DSN Contacts with the Polar and Wind Spacecraft

We will support one scheduled Polar commanding session per day. We will support emergency operations when instrument or spacecraft health and safety require it.

We will support one Wind commanding session per week. We will support emergency operations when instrument or spacecraft health and safety require it.

The FOT will be trained with the Polar Spacecraft Engineer to handle Polar tape recorder management issues to minimize the number of Polar data download sessions per day. We will start with the current three Polar download sessions per day.

We will support one or fewer Wind data downloading session per day and three or fewer Polar downloading sessions.

The budget below is based on the existing rate of one contact for Wind per day and four for Polar.

We will work with Polar Engineers and DSN staff to develop "lights out" automated procedures for Polar and Wind data dumps. Our existing automated paging software can be easily adapted to get operators in to handle "problem" Polar contacts quickly. We recognize there will be some loss of Polar data. We will monitor and report data acquisition loss on a percentage basis weekly. We understand that the requirement is for 90% recovery and that, for short periods, 80% recovery is acceptable. When the monthly average recovery rate falls below 90%, we will produce a report for NASA outlining the reasons for the low recovery rate and suggest, where appropriate, additional resources to improve the data acquisition rate.

We will follow the same procedures for Wind with the understanding that required recovery rate is 85%.

To validate the SSL operations software and hardware, we will develop and implement a three month transition plan. It will begin parallel operations at SSL and Goddard with primary control at Goddard. It will end with full operations being performed at SSL.

3.2: Spacecraft Engineering Health and Safety

During staffed contacts, spacecraft health and safety will be monitored by the Berkeley FOT using the TPOCC ground system. The current Wind/Polar FOT and the Spacecraft and Instrument Engineers will train the Berkeley FOT in all aspects of monitoring the health and safety of Wind and Polar. All downlinked housekeeping telemetry will be monitored by autonomous software. Out of limit conditions will result in pages and emails being sent to relevenat members of the Berkeley FOT..

There is no commanding or monitoring requirement for Geotail.

As noted in section 2.4 above, we will translate existing plans for anomaly response in place at Goddard and implement them when out of limits conditions are encountered.

We will report instrument and spacecraft anomalies to the cognizant PI representative as well as the designated Software Engineer and NASA contacts by phone as rapidly as possible. We will follow up with a written report distributed by e-mail within one week.

If the out-of-limits conditions encountered are not covered by existing contingency plans, we will work with the Spacecraft and Instrument Engineers at Goddard to develop and implement response plans. If appropriate, we will include affected PI teams in the response planning effort.

We will provide a summary report of monthly operations activity to cognizant NASA managers by e-mail and maintain the report on a web site accessible to everyone.

3.3 Payload Engineering Health and Safety

If TPOCC can decomutate payload telemetry, then it will be monitored in the same fashion as the spacecraft.

If not, we will obtain information from current Polar and Wind operations documentation and operators on the telemetry words used to determine instrument health and safety. We will implement these “monitoring points” in the control software to monitor health and safety of the Polar and Wind spacecraft during the initial and final phases of every contact.

We will monitor all Polar and Wind instruments during each contact to ensure that all identified “monitoring points” are within limits. We will report instrumental out-of-limits conditions by phone to one of the individuals identified as a PI instrument contact. We will also notify by phone a designated Polar or Wind contact person at Goddard. We will follow up with a written report of the out-of-limits condition by e-mail within one week.

We will support NRT commanding sessions by PI teams for routine instrument maintenance or in response to instrument emergencies.

We will follow procedures currently in place for sending PI commands to their instrument. Commands are to be provided by FAX or e-mail to the SSL operations center. The timing and/or order of commands can be changed by verbal notice during the contact, but no new commands will be constructed in response to verbal instructions.

3.4 Maintenance of Instrument GSE’s

Polar/CAMMICE/CEPPAD and Polar/VIS instruments currently use PI-provided GSE’s physically located near the Goddard Polar/Wind operations center. These GSE’s are provided the full Polar Level 0 data stream connected to the near real time data stream through a “rack” of equipment connected to the operations console. Access to the GSE’s by the CAMMICE/CEPPAD PI’s is by dial-in modem. Moving the “rack” of equipment and interface from Goddard to SSL is possible, but it will involve a significant “down” period during which it will not be possible to access the GSE’s. We will therefore work with the VIS team at the University of Iowa and the CAMMICE/CEPPAD team at the Aerospace Corporation to provide the functionality currently provided by their GSE’s at Goddard.

For the VIS team, their GSE interface is a backup for times when the NRT data server is not available. As noted below in section 3.5, we will institute procedures and train all SSL operations personnel to verify that the Polar and Wind NRT data server is operating correctly before every commanding session. A reliable NRT data stream is important to all Polar and Wind investigators. SSL personnel are committed to making the NRT data stream more reliable than it currently is. We will work with the VIS investigators to determine their requirements for uptime, and we will probably be able to provide it thus eliminating the VIS requirement for a GSE.

For the CAMMICE/CEPPAD team, the GSE is the primary interface to the NRT data stream required to support instrument operations. It is unclear which is the more difficult and/or riskier task for the CAMMICE/CEPPAD team:

A) Reengineering their GSE to accept the NRT input at SSL instead of the custom output provided by the "rack" at Goddard;

B) Physically moving the "rack" and interfacing it to the full level zero data stream at SSL; or

C) moving operations to SSL but physically leaving the "rack" and CAMMICE/CEPPAD GSE at Goddard and having it "tended to" by the Polar Instrument Engineer as one of his/her duties.

We will explore these alternatives with the CAMMICE/CEPPAD team as well as other approaches they suggest. We will discuss the alternatives and agreed upon solution with the Polar project scientist before proceeding to implement it.

The proposed budget does NOT include the costs of implementing functionality to replace that currently provided by the VIS, CAMMICE, and CEPPAD GSE's at Goddard.

3.5: Continuation of the NRT data stream

We will adapt existing code and implement it on computers at SSL to produce Polar and Wind LZ data products from real time (not tape recorder) data and provide them over the Internet in the same format with the same protocols currently implemented on the ISTP6 VAX at Goddard. We will implement this procedure on a Unix box so details of the interface, such as username/password protocol, will be different. Some modification of the NRT data interfaces will have to be done by the PI teams. We will provide personnel to maintain a high level of availability of the NRT data streams to the Polar and Wind PI sites.

We will provide testing and parallel operations of the NRT data servers to facilitate transition from the ISTP6 server at Goddard to a SSL server.

3.6 Continuation of Quicklook data products

The QL data product is best associated with the ground data processing task (see section 3.6 of the data processing chapter), not the operations task. If SSL is selected to perform the ground data processing as outlined above, we will provide limited production of QL data products.

Validation of Operations software and procedures

Transition of Polar and Wind operations from Goddard to SSL requires the translation and interpretation of a large number of codes and procedures. Most, but not all, of the critical information has been documented by the current operations contractor. The risks associated with the transition will be mitigated to a large extent because we do not envision replacing the personnel currently at Goddard who perform Instrument and Payload Engineering tasks under the existing operations contract. We assume that these people will be retained through some TBD mechanism that does not involve SSL. As noted above, we are planning to rely on them for contingency and special operations but will reduce or eliminate reliance upon them for daily activities..

We will involve these Goddard engineers in the design and translation of the operations. We will provide a detailed and specific plan, in a style similar to a preliminary design review (PDR) to Polar and Wind PI's as well as Goddard personnel shortly after beginning the development process to ensure that all relevant tasks have been identified and our approach to them is valid. We will host a site review before the interval of parallel operations to further validate the processes and procedures we have implemented. Additionally we will host a second site review about half way through the transition process to ensure that everyone is comfortable with SSL taking on full operations.

Estimate of costs of operations

Costs are shown here as man-months (mm), man-weeks (mw), or full time equivalent (FTE). A summary and translation to dollars is given at the end of this study.

Development:
   Visit by two Controllers to Goddard to train on current operational systems 4 mm
   Visit by DSN scheduler to Goddard to train on current policies and procedure 1mm
   Acquire and set up CMS, TPOCC, and other operational computer systems 13 mm
Subtotal 18 mm

14 Week Three Validation/Transition period:
  A. Normal operating personnel at 3.0 FTE 10.2 mm
  B. Support staff 4 mm

Subtotal 14.2 mm

Continuing Operations:
  Sections of the requirements document:
    1.4 Receiving commands from PI's and Goddard Engineers
    2.1 Preparation of spacecraft commanding sequences
    2.4 Special operations planning and scheduling
    1 FTE
  Section 2.2: Provide ranging information to FDF nil
  Section 2.3: DSN scheduling (we will use existing procedures) 1/2 FTE
  Sections of the requirements document:
    3.1 DSN contact with Polar and Wind
    3.2 Spacecraft Engineering Health and Safety
    3.3 Payload Engineering Health and Safety
    3.5 Continuation of the NRT data stream for Polar and Wind
    1.5 FTE

Subtotal 3 FTE

Travel Costs:
  one team of two Spacecraft controllers for 2 months to GSFC - $10K
  one DSN controller for 1 month to GSFC - $5K
Total - $15K

Required additional hardware:
  3 Sun Workstations - $9K
  9 Uninteruptible Power Systems (UPS) - $1.8K
  2 PC's for SERS (Spacecraft Emergency Response System) - $3K

Security System Upgrade - $1.5K
Building Generator Upgrade - $15K
Total - $30.30K

The proposed budget does not include the costs of implementing functionality to replace that currently provided by the VIS, CAMMICE, and CEPPAD GSE's at Goddard.

Summary of taks in the requirements document that SSL does NOT feel it can efficiently take on in the near term

1.1: Event Identification
As noted in the requirements document, this will become completely a PI function.

1.2: Definitive Orbit Information
Definitive orbit information will not be produced for Polar or Wind as noted in the requirements document.
We will not produce polar platform attitude data files, predictive or definitive. These files are used by the three imaging investigator teams and require detailed knowledge of the platform operation and operational history. Production of these files is best done by one of the imaging teams.

1.3: Polar Despun Platform Pointing Planning
We will work with the group or individuals who generate the Polar despun platform planning files to make sure that they have timely access to the Polar orbit and attitude files required for their work. These files are used by the three imaging investigator teams and require detailed knowledge of the platform operation and operational history. We will NOT produce them.

3.4: Maintenance of Instrument GSE's
As noted earlier, the requirements for maintaining the GSE's can be met in alternative ways. We will explore with the affected Polar PI science teams (VIS, CAMMICE, and CEPPAD) as many alternative approaches to meeting their near real time data requirements. The fall back position is to leave the rack of equipment serving the GSE's and the GSE's in place at the Goddard operations center with required support personnel paid for by the Polar/Wind project.

3.7: Data Processing, Archiving, and Distribution
To minimize operational complexity, we will maintain files for each data product in only one format. For this reason, we will NOT produce sirius level zero files for Geotail or associated SFDU files for any data products.
To minimize complexity, remote access to "pull down" data from SSL servers will have only a modest level of security. No provision will be made for restricting access to multiple groups data types to designated PI teams. It will therefore be possible for anyone with access to the server to pull down data from all Polar, Wind, and Geotail investigations.

3.9: KP Generation

The po/wi/ge_k0_spha files are named as key parameter files. They are actually attitude files and will be produced and distributed as discussed in other sections. Other Key Parameter (KP) files are instrument specific. They require a detailed knowledge of the instrument and its operational history. These data products are best produced by groups with easy and direct access to the many individuals holding undocumented knowledge about the state and operation of the various instruments. We will NOT undertake the difficult and complex task of posting existing KP software to a new environment.

3.10: Definitive Orbit and Attitude Data

Definitive orbit and attitude data for Polar and Wind were discontinued previously as part of an earlier re-engineering effort. If the responsible NASA officials determine that the predictive orbit and attitude data are inadequate for data analysis, we will produce and distribute updated versions of the attitude and orbit files as required.

3.11 Ancillary Data Ingestion

We will NOT assemble and pass through to NSSDC data sets other than those from Wind, Polar, and Geotail described above. We do not feel that we can provide any value added services, only costs to this processing.

3.12 Data Distribution

On request of, and with appropriate supplemental funding from the Polar project scientist, we will make custom CD's for Polar or Wind PI teams. We have no plans to make custom CD's for Geotail investigators.

Summary of important qualifications made above

1) We will use the reengineered Goddard Command Management System (CMS). Also, we will need to acquire the TPOCC system currently in use by the Project.

2) We will not replace the functions of the FDF. We will develop interfaces to get and receive information from them.

3) We will not replace the functions of the Spacecraft and Instrument Engineers at Goddard. We will develop policies and procedures to provide them with information in a timely manner as well as procedures to endure that their advise and consent is obtained in a timely manner. We will rely on them for planning and advising battery management, tape recorder management, thermal management, maneuver planning, and anomaly resolution.

4) We will not do Polar despun platform planning.

5) We will not initially consider implementing processing of instrument specific KP files from LZ data. If the need for this function can not be met by PI teams or other groups, we will consider taking it on.

6) We will not generate SFDU files.

7) We will not generate sirius files.

8) We will not support “pushing” files to PI sites using scripts running at SSL. Investigators will have to pull their data from our ftp sites.

9) The proposed budget does not include the costs of implementing functionality to replace that currently provided by the VIS, CAMMICE, and CEPPAD GSE’s at Goddard. We will work with the PI teams to meet their needs to near real time data currently met by the GSE’s. An extensive discussion of the options and fall back position is given above.

10) To the extent possible, we will use a “lights out” approach to data acquisition. We will also try to work to 3 Polar and less than 1 Wind contact per day to more fully use the available tape recorder capacity. The budget and schedule above are based on 4 Polar and 1 Wind contacts per day.

11) We will not participate in ancillary data ingestion. It does not make sense for us to put an additional layer between the data providers and the CDAWeb.

12) The primary source for assistance to PI teams in building commands in response to instrument anomalies will remain with the Instrument Engineers at Goddard. We will assist the Instrument Engineers and PI teams as required to generate new command sequences in response to instrument anomalies.

Summary of Estimated Costs

Transition staff cost will be 4.3 FTE.

Our core continuing support staff will be made up of:
  2 full-time Data Processing Staff - 2 FTE
  2 half-time Data Processing Staff - 1 FTE
  2 half-time Spacecraft Controllers - 1 FTE
  2 half-time Spacecraft Engineers - 1 FTE
  1 half-time DSN scheduler - 0.5 FTE
  1 half-time Operations Manager - 0.5 FTE
  System Administration - 0.5 FTE
Total - 6.5 FTE

Transition hardware costs include:
  7 Sun Workstations (Ultra 10’s) @ 3K each - $21K
    4 of these Workstations would be used for data processing, the other 3 by the FOT.
  11 Uninterruptible Power Supplies (UPS) @ $200 each - $2.2K
  2 PC’s (for SERS, our Emergency Response System) @ $1.5K each - $3K
  Disk Storage - $5K
  Security System Upgrade - $1.5K
  Building Generator Upgrade - $15K

Total - ~$50K

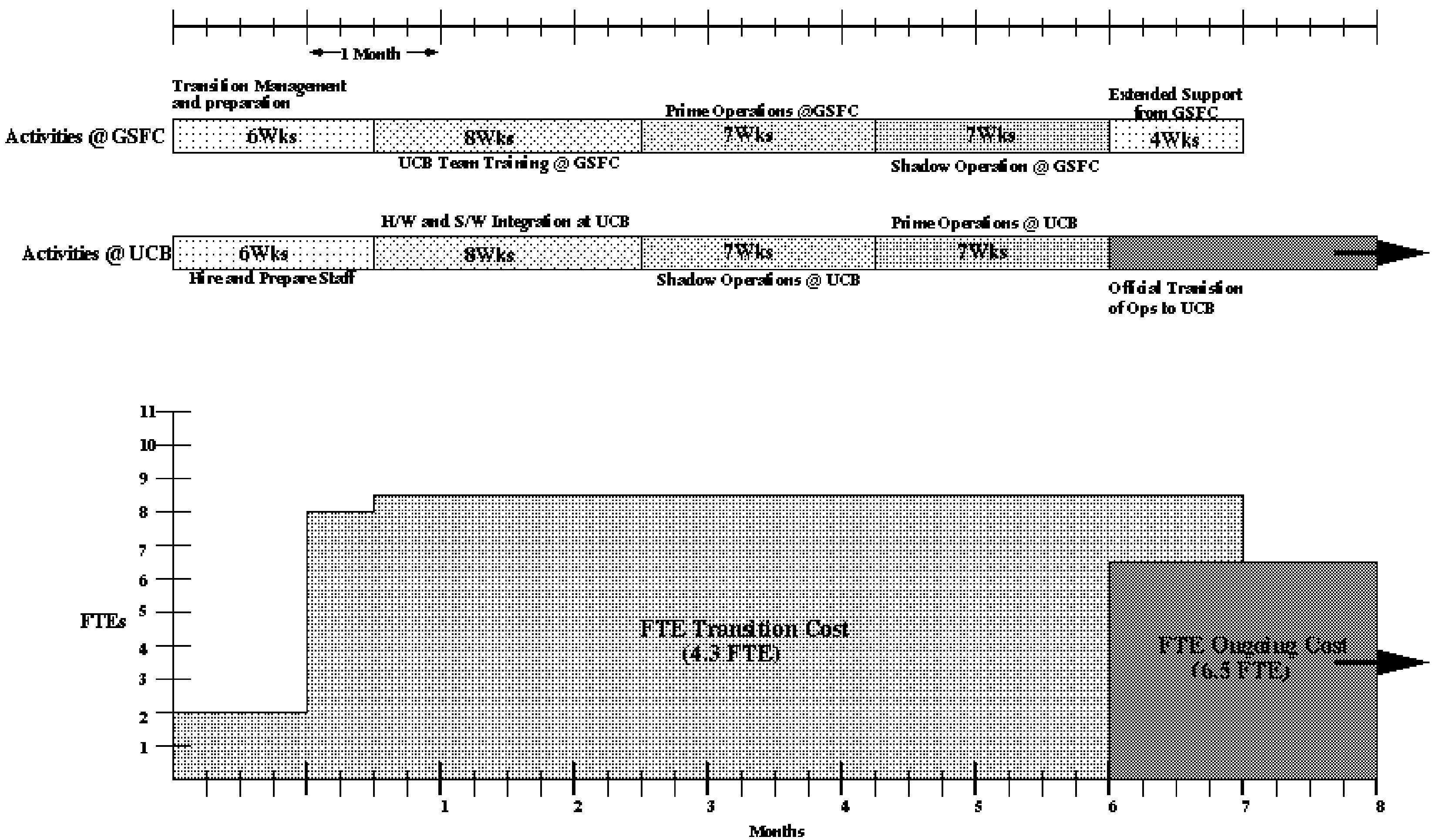
Ongoing Hardware/Software Costs:
SERS (Spacecraft Emergency Response System) Support $5K/year
Supplies (CDROMs, disk drives, etc.) $5K/year
Total - $10K/year

Travel Costs:
2 Data Processing Staff to Goddard for 1 month - $5K
2 Spacecraft Controllers to Goddard for 2 months - $10K
1 DSN Controller to Goddard for 1 month - $5K
Total - $20K

Proposed Schedule

We nominally propose to begin preliminary functions such as orienting ourselves with GSFC and hiring staff on 2/1/2002. A full team of mission operations and data processing personnel would be in place on 3/1/2002. The following diagram schematically represents the transition period. 8 weeks would be set aside for hardware and software integration and 14 weeks would be devoted to the transition phase. The official transition to SSL operations would occur 8/1/2002.

Estimated Transition and Cost Schedule for Wind/Polar



Additional Tranistion Costs:

Hardware = $50K
Travel = $20K

Ongoing Costs = $10K/Year
(Includes maint. contracts, supplies, etc)